Mathematical Analysis of Redistricting Plans in Utah

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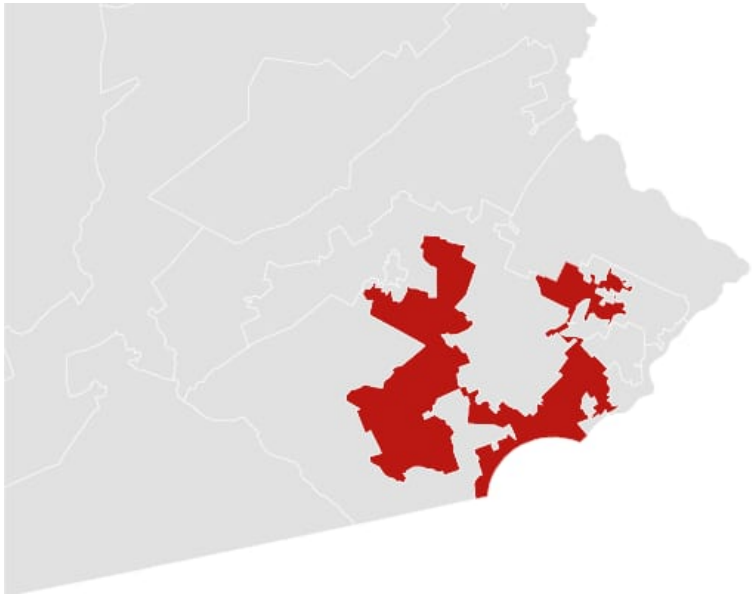
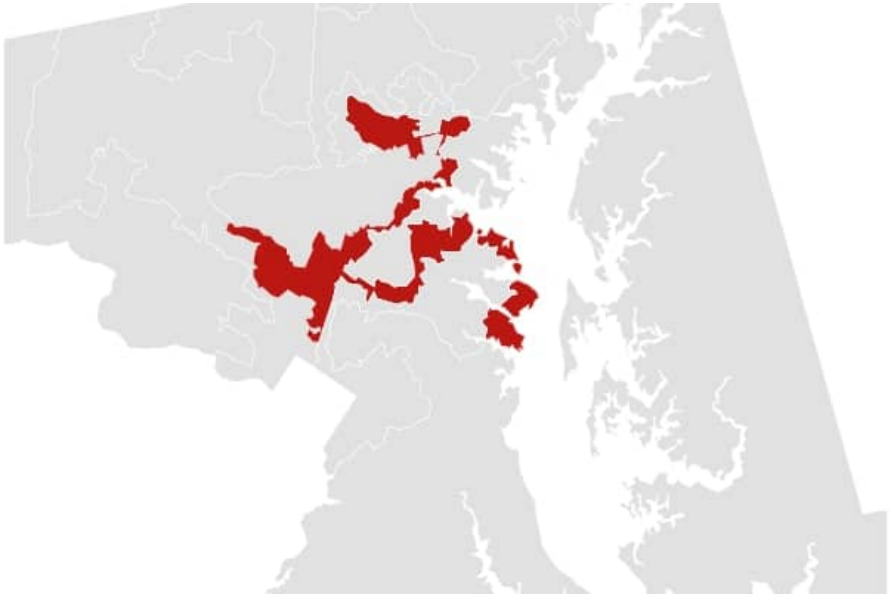
Identifying a Gerrymander

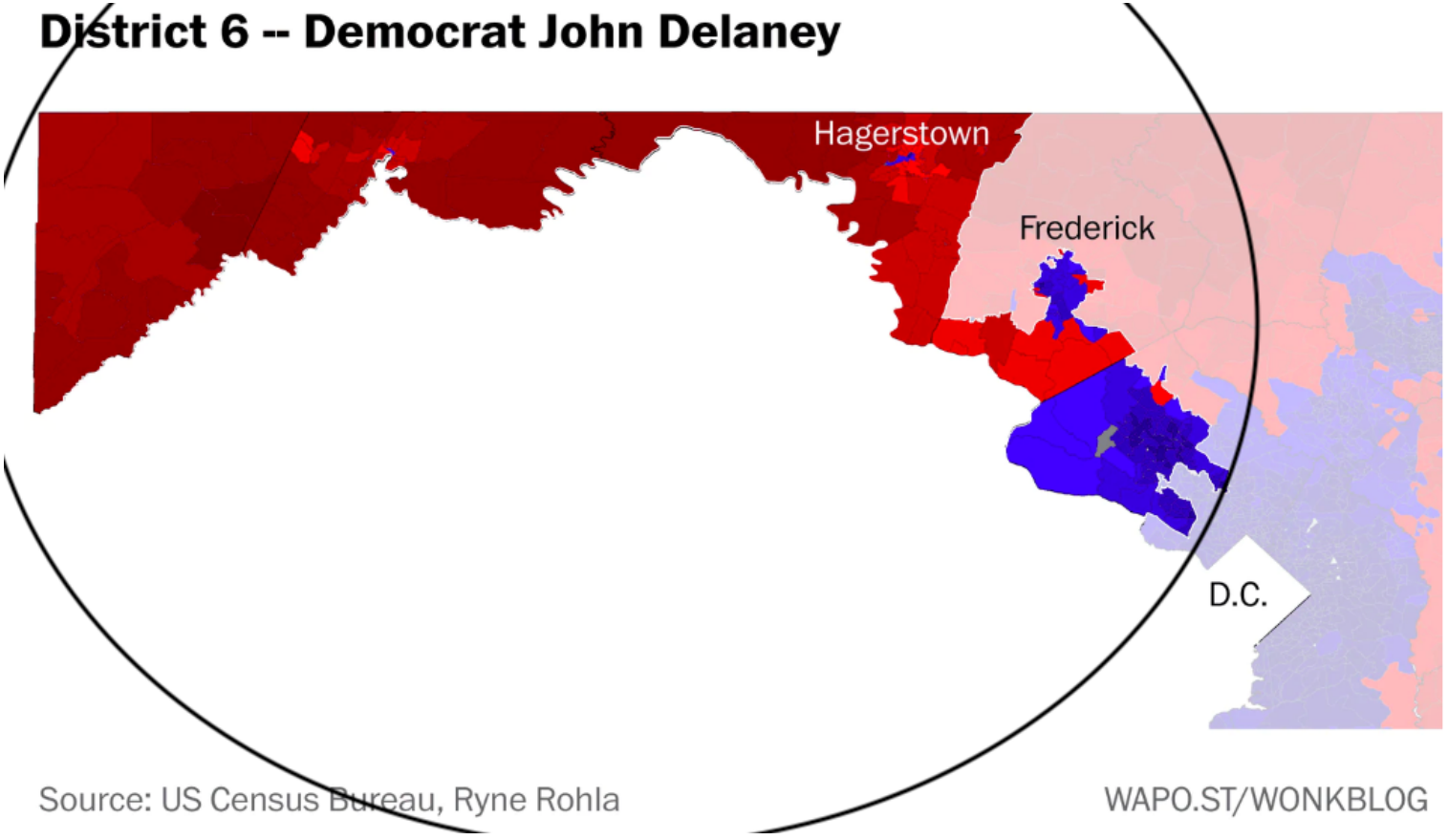
Identifying a Gerrymander: Compactness

Compactness

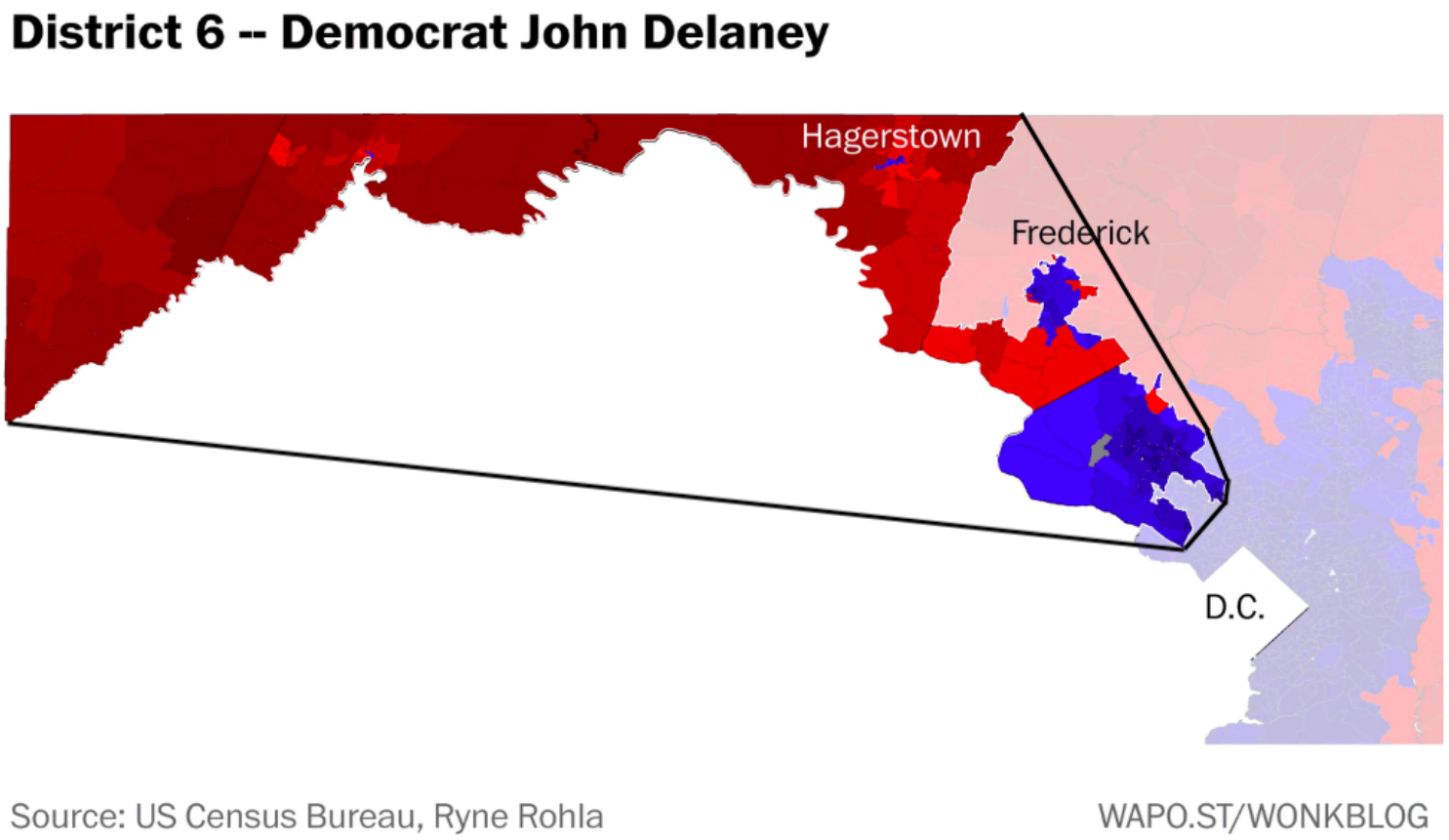




Compactness: Reock score



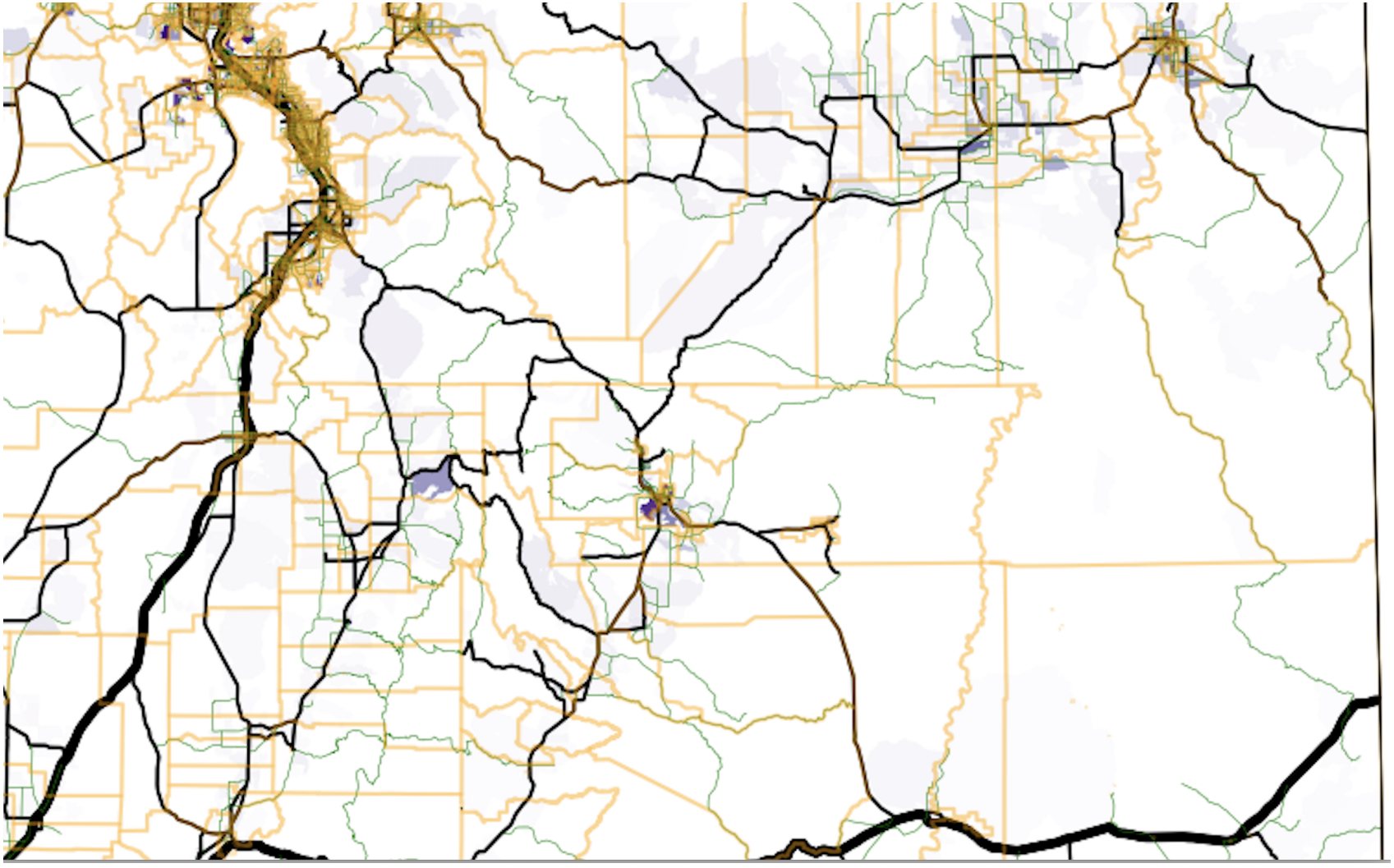
Compactness: Convex hull



Compactness

- Many unfair maps are compact
- Other factors cause odd shapes
  - Geographical boundaries
  - Communities of interest
  - VRA constraints
  - Road connections

Compactness: adjacent precincts w/o roads



Compactness Summary

- Many unfair maps are compact
- Some fair maps are not compact
- The shape is not the goal

Seats and Vote Shares

Utah Senate 2010 (Lee v. Granato):

65% R and 35% D

Naïve assumption: Seats should be proportional

Fair ≠ Proportional

One extreme:

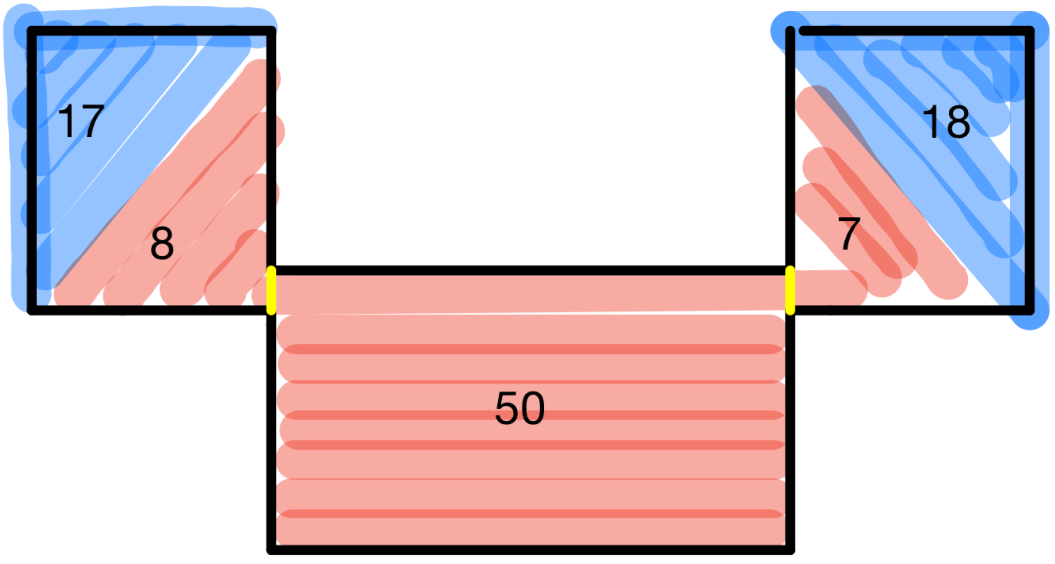
Every household 65/35 forces all seats to majority

Massachusetts:

- Approximately 34/66 Republican/Democrat
- 9 seats possible
- No Republican elected since 1994
- No plan **can** give even one Republican seat

Fair ≠ Proportional

Another extreme: 65/35 highly separated



Geometry forces 2 out of 4 seats to minority

Utah 2011 Congressional seats

Utah 2011 could have at most one Democratic seat

- What's fair or reasonable? 1 seat or 0?
- A better measure: Vote share in Least-Republican district

How to Identify Fair/Reasonable

Old way: single score based on abstract argument

- Compactness scores
- Partisan symmetry scores:
  - Partisan bias
  - Partisan Gini
  - Mean-median
- Efficiency gap

Drawback: these are poor indicators of fairness

How to Identify Fair/Reasonable

Better way: Ensembles
A large sample of possible plans

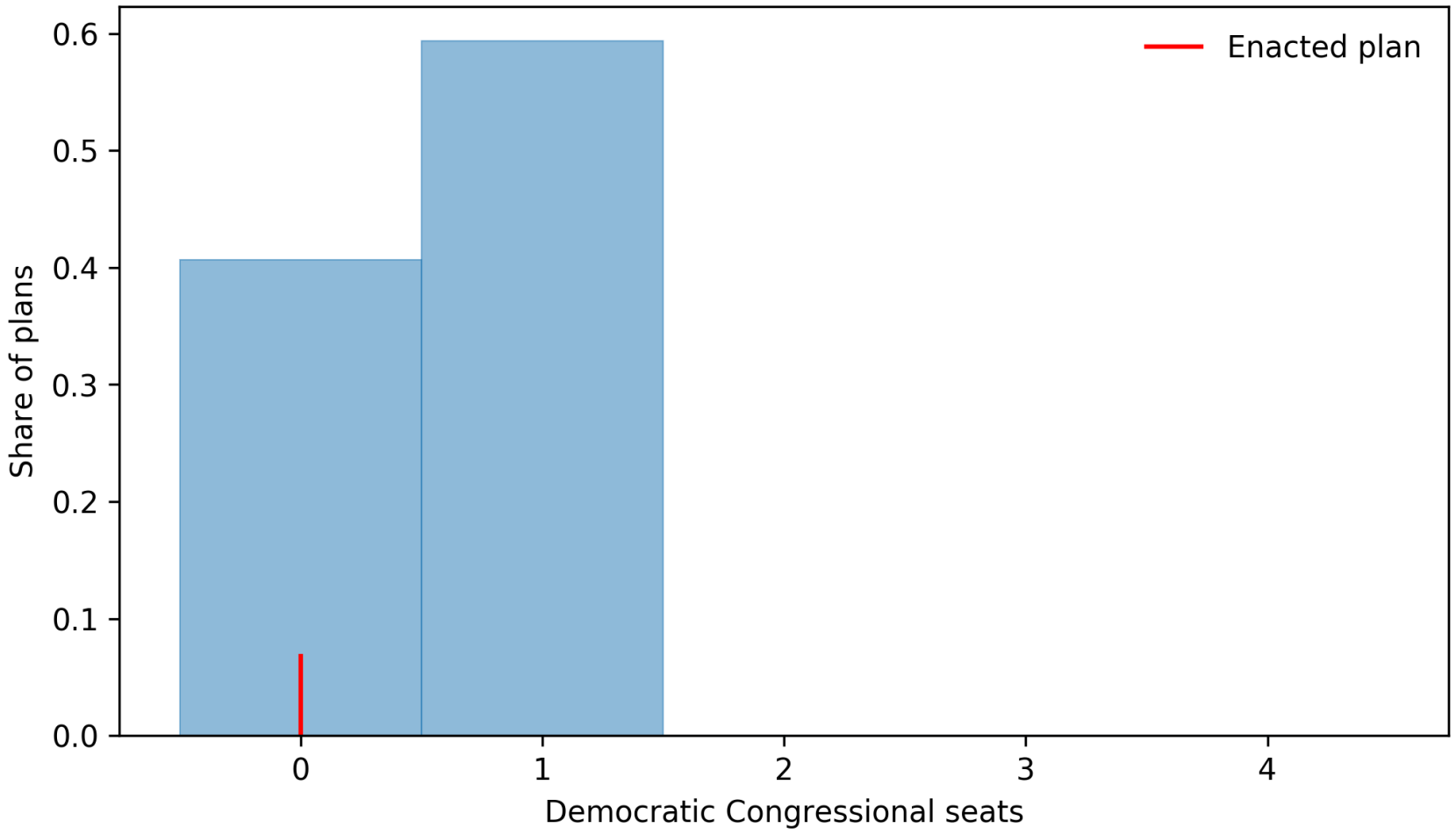
- Independent of partisan information
- Meeting all stated requirements:
  - Population equality
  - Contiguous
  - Relatively compact

Compare proposed plan to the ensemble

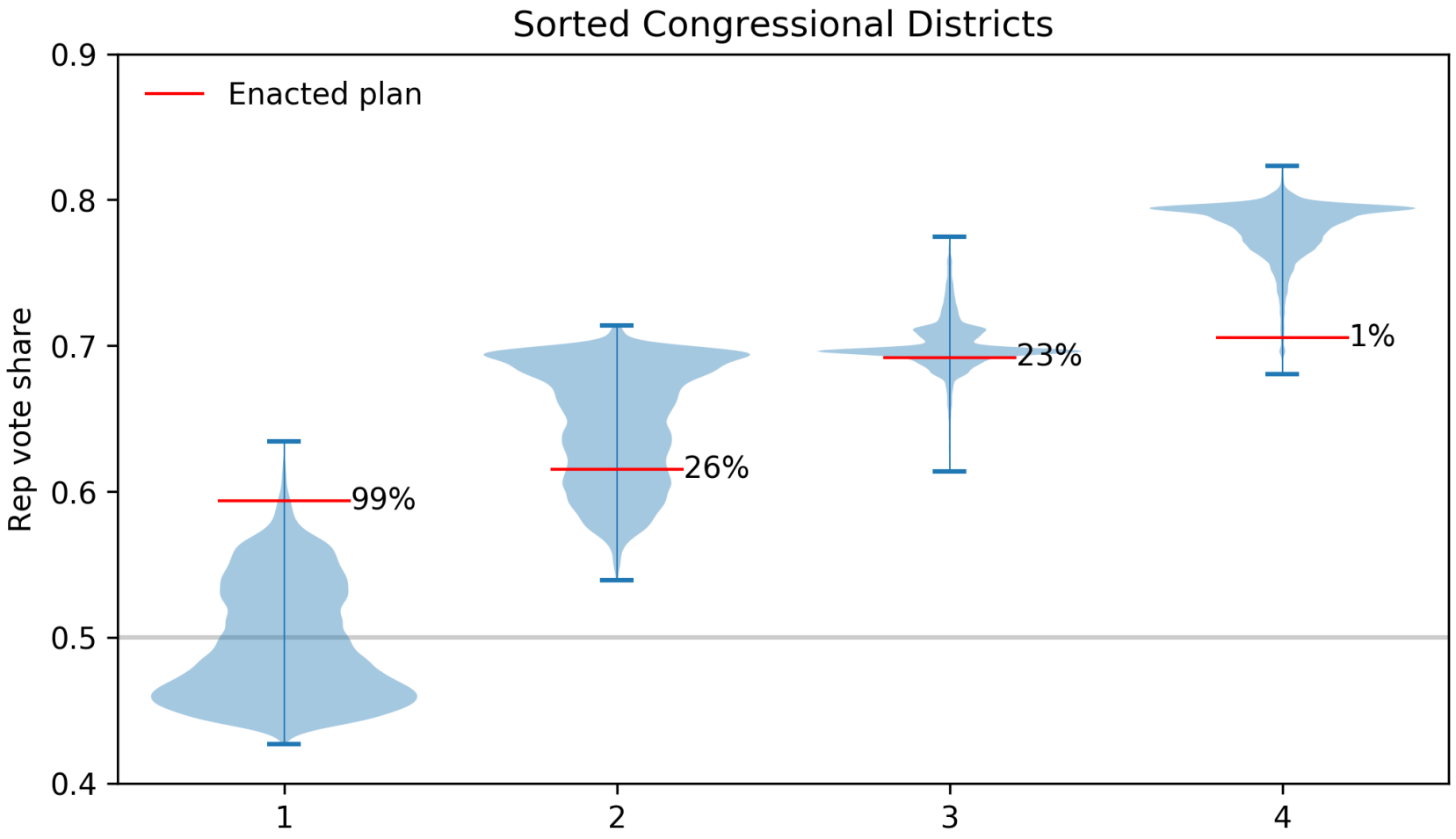
Ensembles

- Made possible by increased computing power
- The best methods
  - Generate many plans
  - Mix well (repeatable)
  - Use Markov chain Monte Carlo (MCMC)

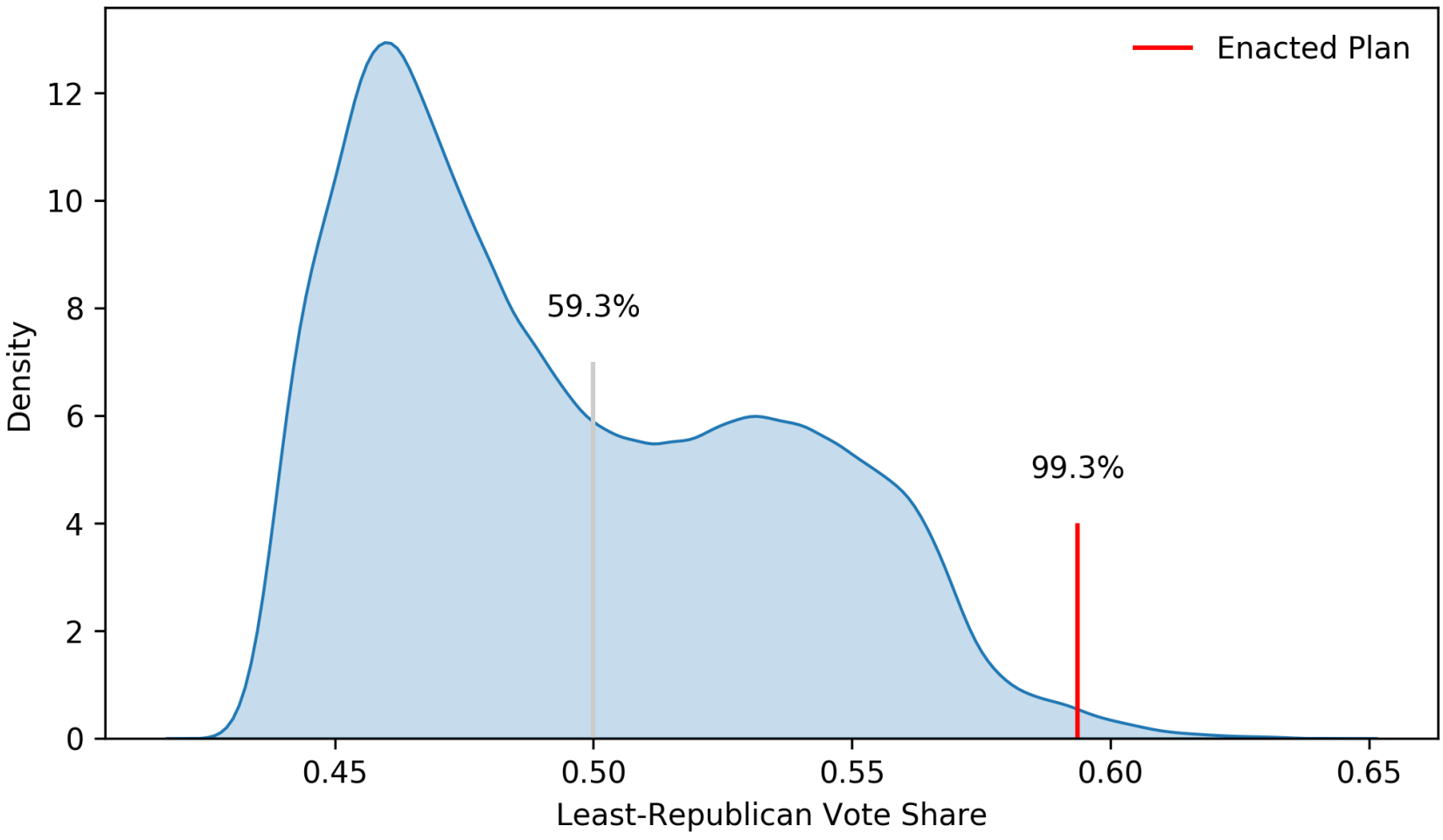
Ensemble of 1M, 2011 US Congressional



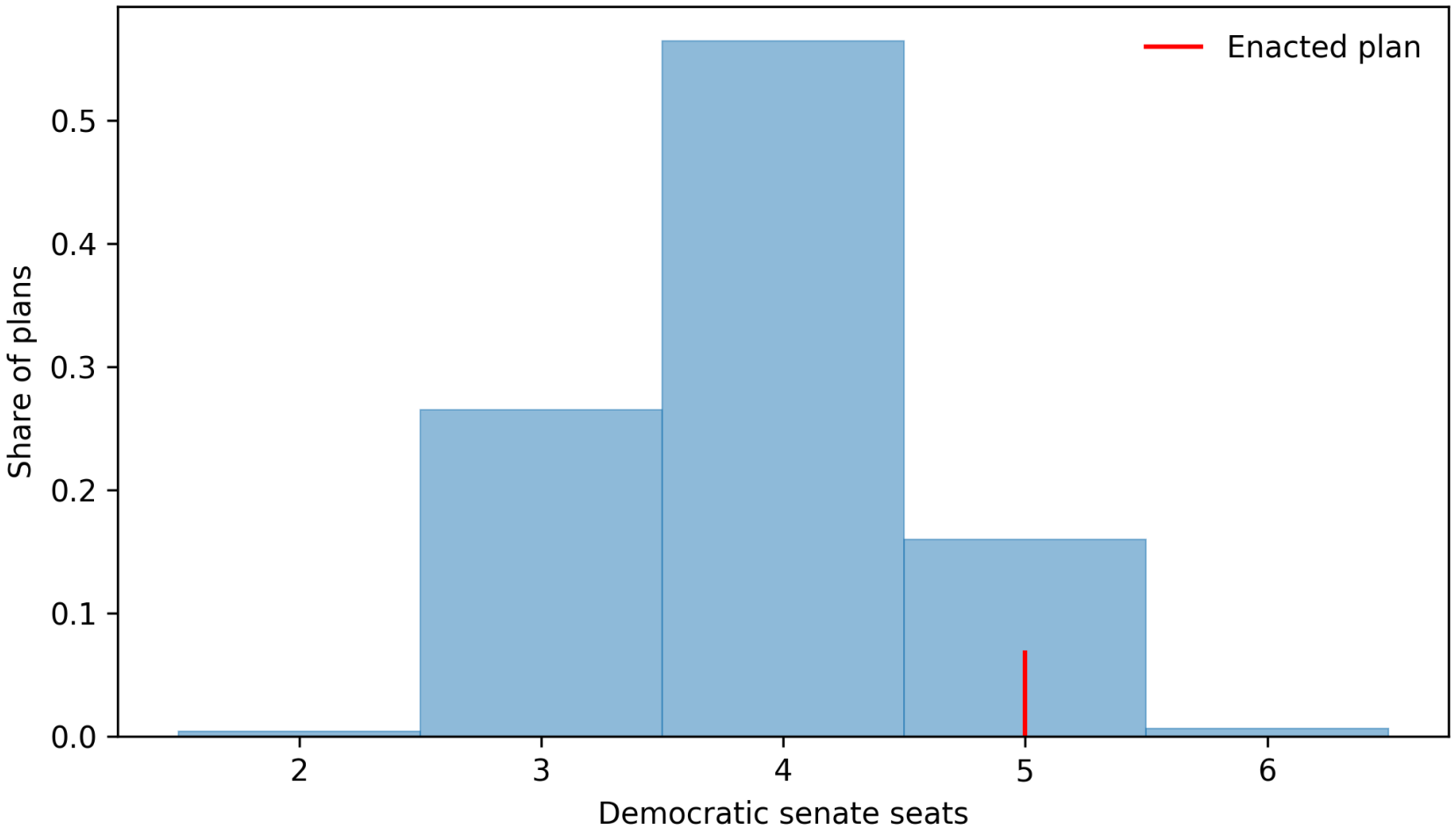
Ensemble of 1M, 2011 US Congressional



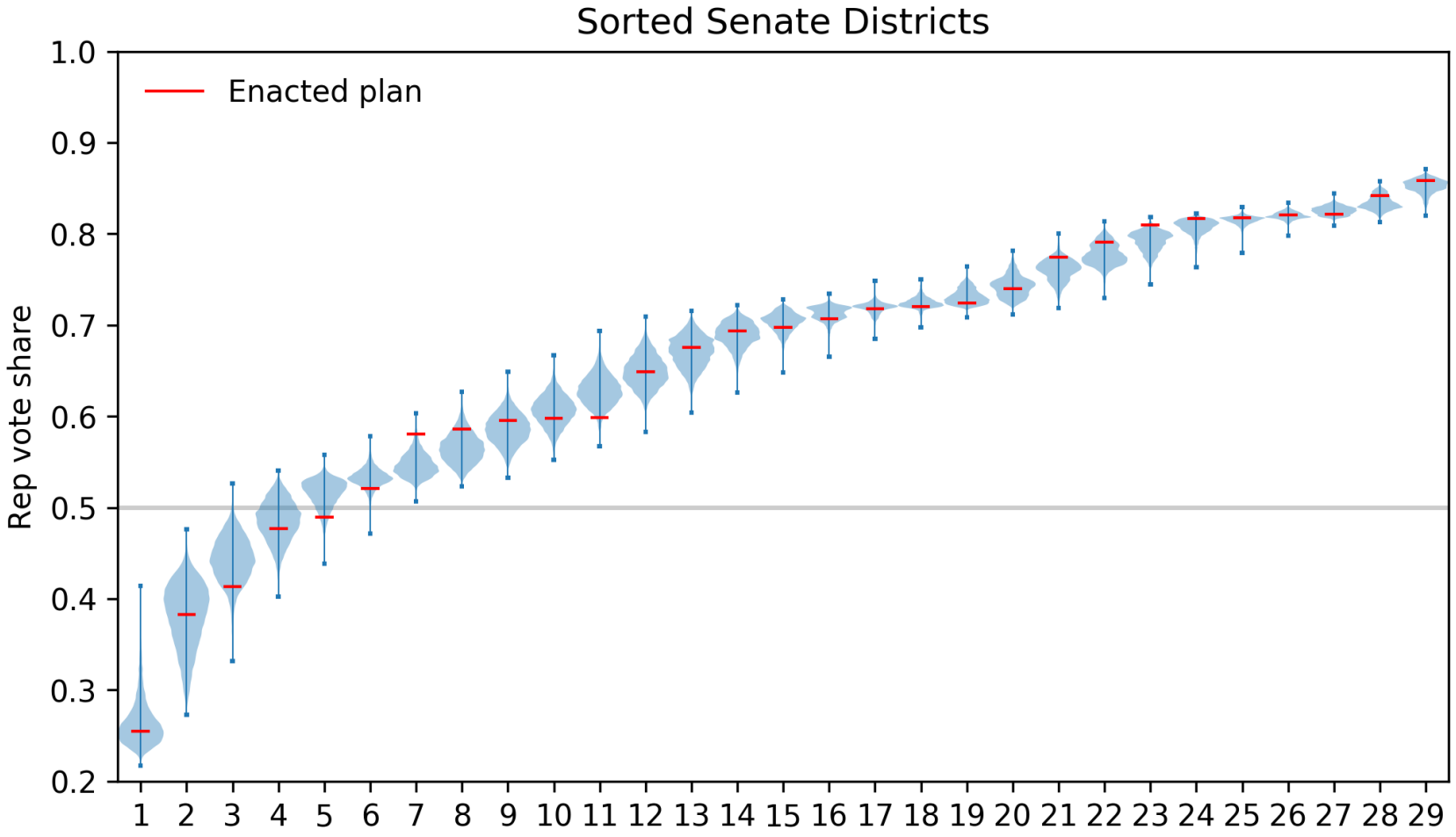
Ensemble of 1M, 2011 US Congressional



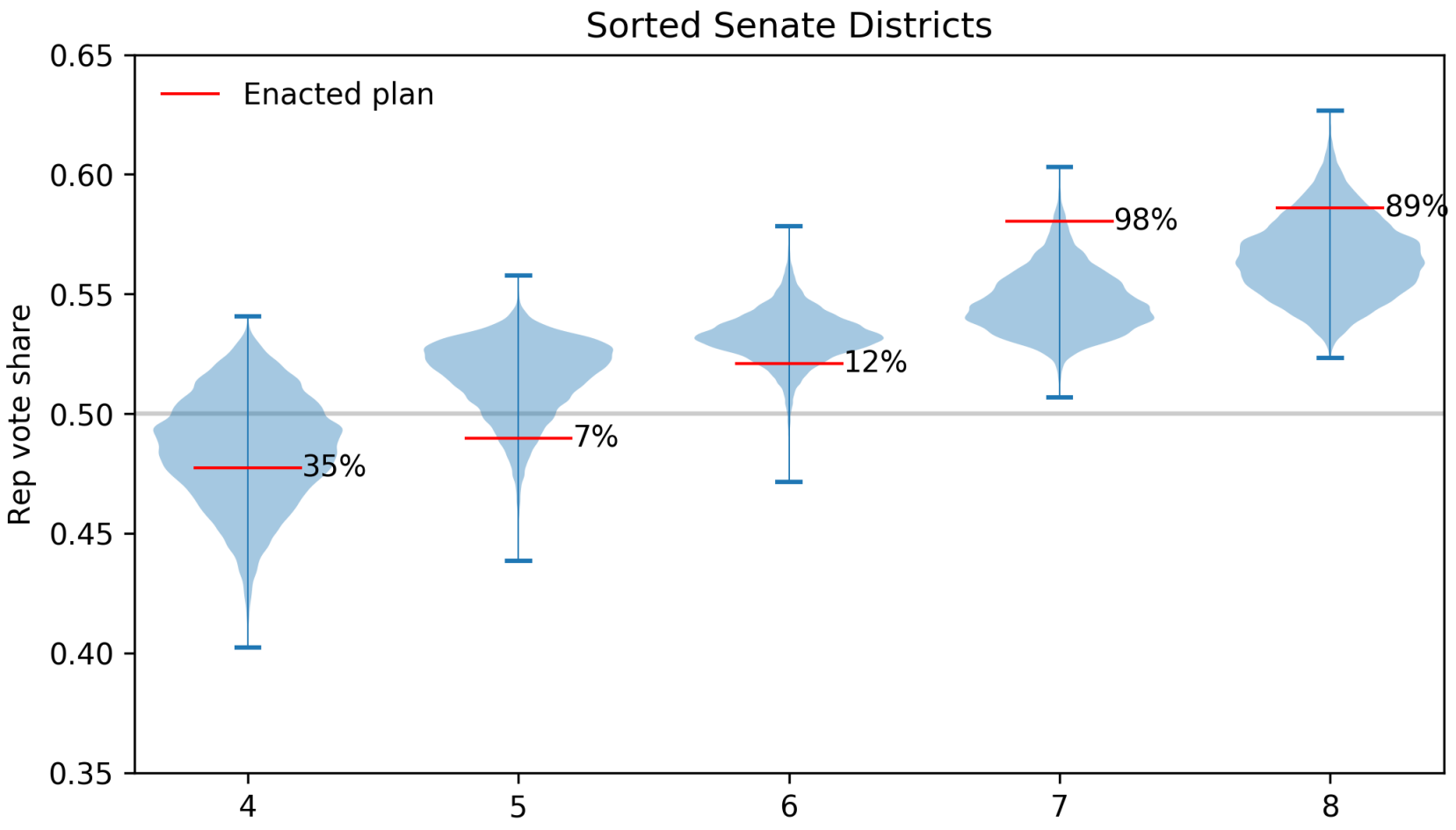
Ensemble of 1M, 2011 UT Senate



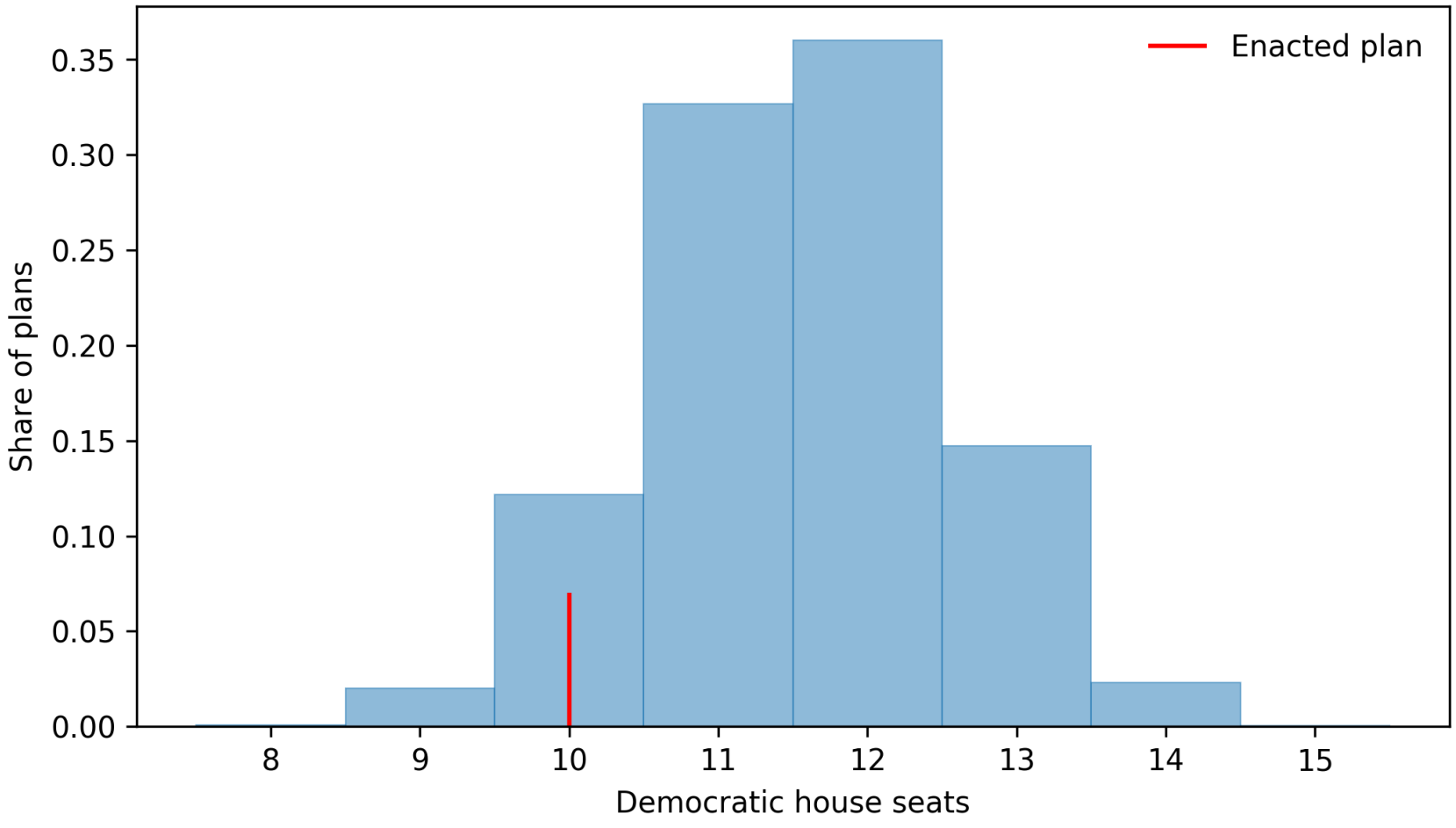
Ensemble of 1M, 2011 UT Senate



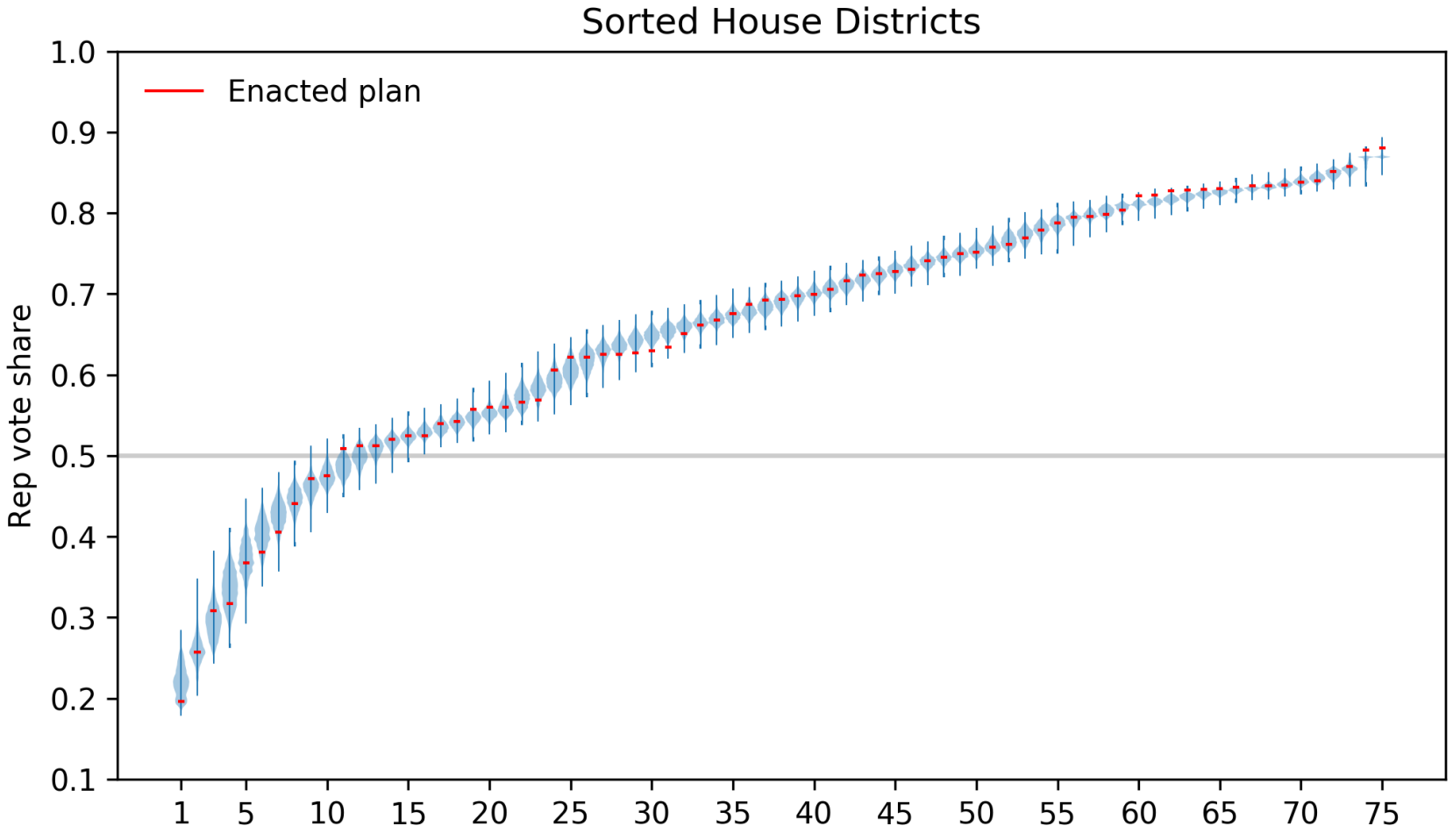
Ensemble of 1M, 2011 UT Senate



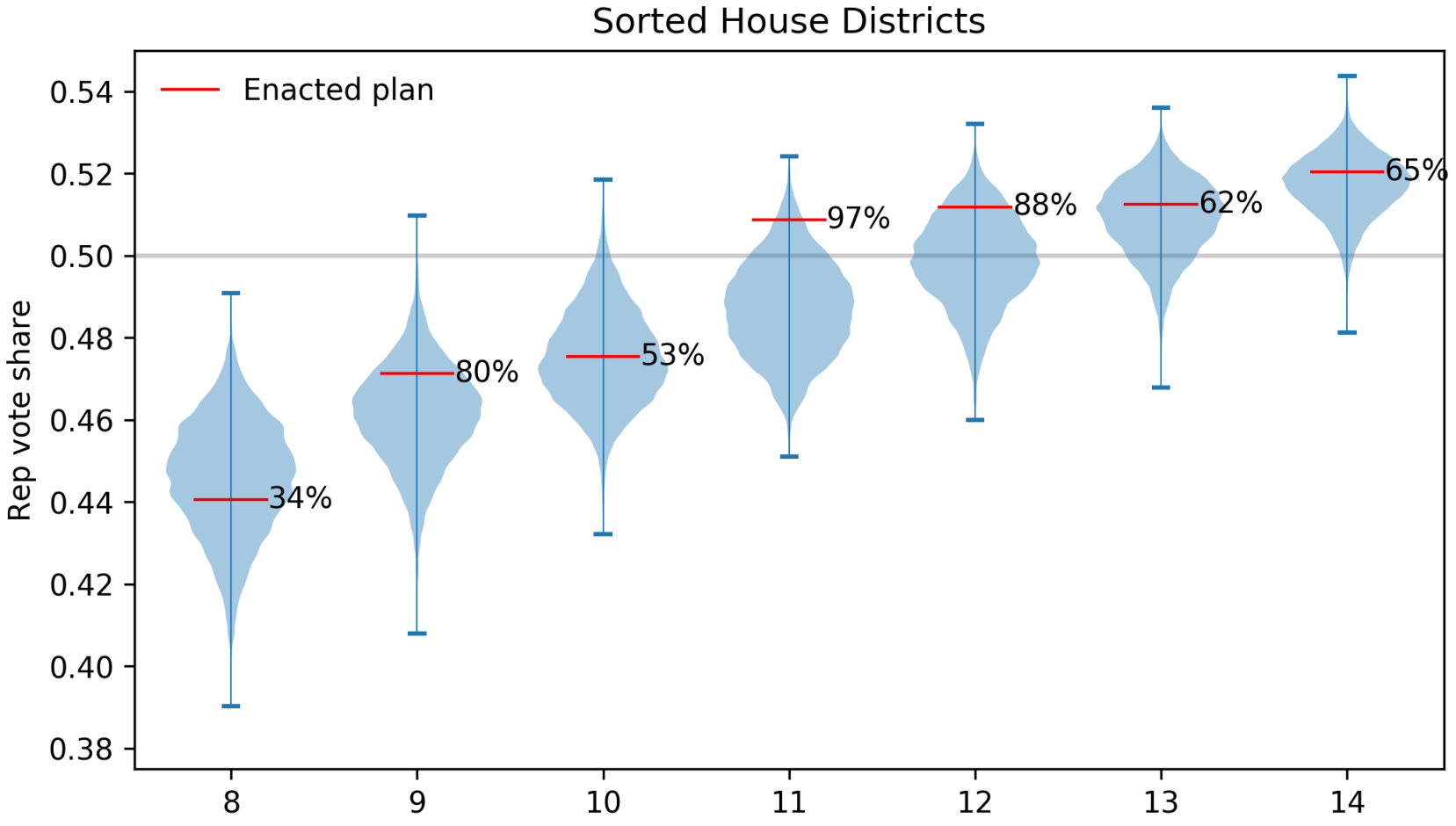
Ensemble of 1M, 2011 UT House



Ensemble of 1M, 2011 UT House



Ensemble of 1M, 2011 UT House



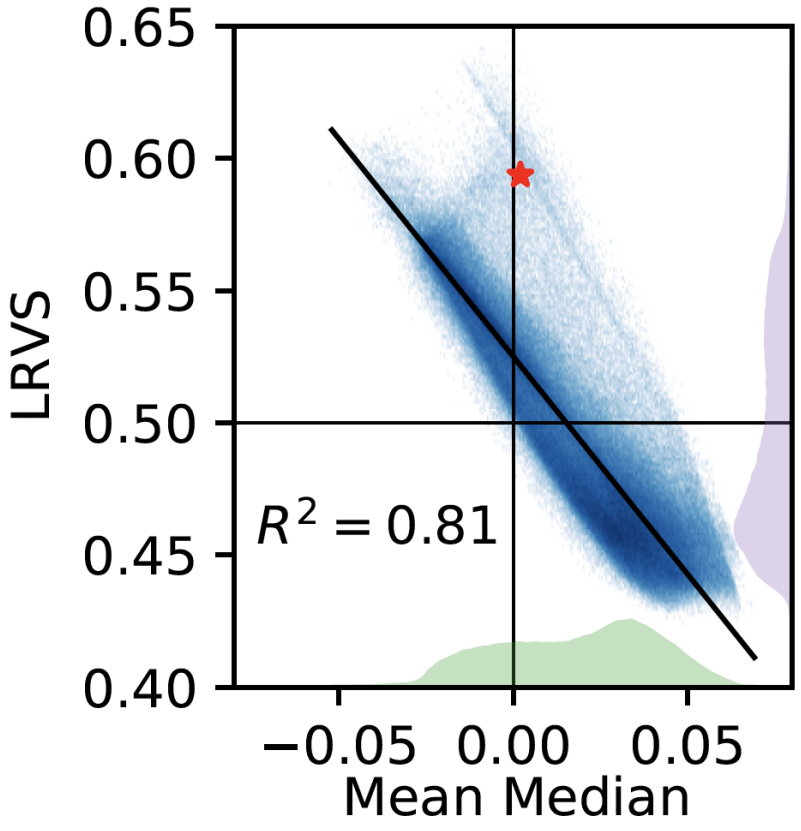
Ensemble of 1M, 2011 Summary

2011 enacted plan

- US Congressional: more Republican than 99%
- UT Senate: more Democratic than 93%
- UT House: more Republican than 97%

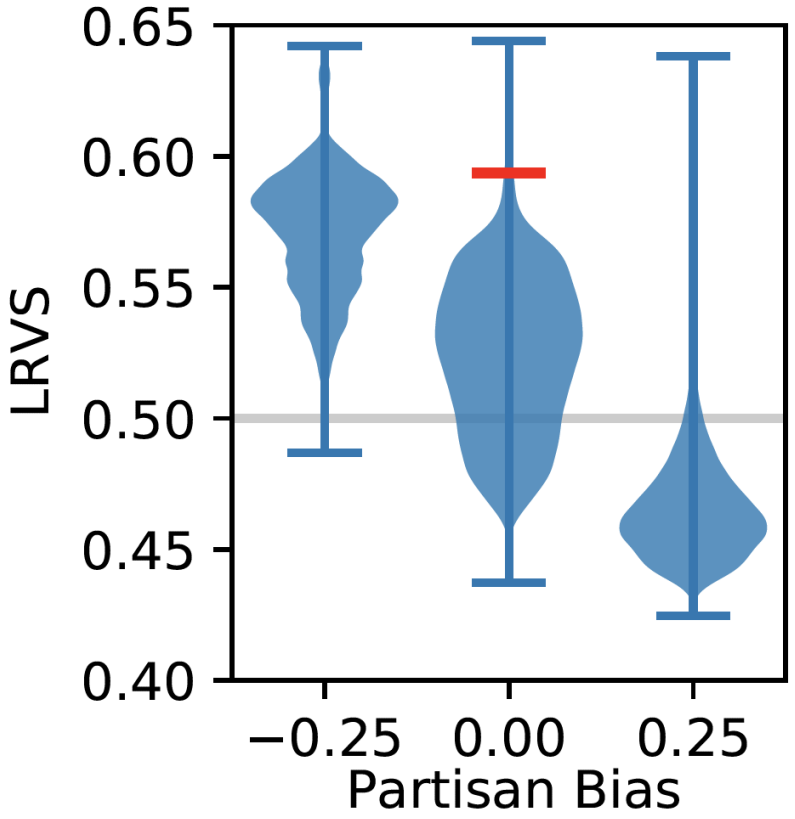
Other Metrics: Mean-Median

Mean-Median is backwards in Utah



Other Metrics: Partisan Bias

Partisan bias is backwards in Utah



Summary So Far

- Political geography has a huge impact
- A single score is inadequate
- Many traditional scores are misleading or uninformative

Solution: Ensemble methods combined with

- natural metrics and
- thoughtful analysis

Requirements: Commission must decide

- Population deviation (1%, 10%?)
- Contiguity: boundary or roads?
- Define communities of interest?
- Preserve municipalities?
- Preserve counties?
- Respect natural boundaries?
- Preserve cores of prior districts?

Ensemble Requirements: Data

Partisan distribution varies from election to election

- Use statewide races
- Avoid incumbents
- Use typical rather than unusual races

Possibilities:

- Senate 2018 (Romney v Wilson)
- Governor 2020 (Cox v Peterson)

Summary

- Political geography has a huge impact
- Use large ensembles & natural metrics
- Requires clear rules for building districts
- Requires choice of election data